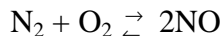


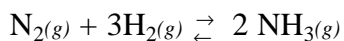
Exam 3. 100 pts. Answer Questions 1- 27 on Scantron. 3 pts each. Answer remaining questions on the exam.

1. When the reversible reaction



has reached a state of equilibrium,

- (A) no further reaction occurs.
 - (B) the total moles of products must equal the remaining moles of reactant.
 - (C) the addition of a catalyst will cause formation of more NO.
 - (D) the concentration of each substance in the system will be constant.
 - (E) the product $[\text{N}_2] \times [\text{O}_2]$ equals $[\text{NO}]^2$.
2. Which is a proper description of chemical equilibrium?
- (A) The frequencies of reactant and of product collisions are identical.
 - (B) The concentrations of products and reactants are identical.
 - (C) The velocities of product and reactant molecules are identical.
 - (D) Reactant molecules are forming products as fast as product molecules are reacting to form reactants.
 - (E) The numbers of moles of reactants and products are equal.
3. At constant temperature, an increased pressure applied to the equilibrium system



will produce what change?

- (A) increase the concentration and amount of NH_3
- (B) increase the concentration and amount of H_2
- (C) reduce the partial pressure of NH_3
- (D) cause crystallization of NH_3

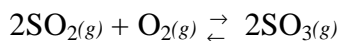
1. For the reaction



carried out at constant volume, the concentration of O_2 at equilibrium will increase if

- (A) SO_2 is added to the system.
- (B) SO_3 is added to the system.
- (C) the temperature of the system is lowered.
- (D) an inert gas is added to the system.

2. For the reaction



carried out at constant temperature and volume, what is the effect of removing some SO_3 from a system initially at equilibrium?

- (A) $[\text{SO}_2]$ decreases more than $[\text{O}_2]$.
- (B) $[\text{SO}_2]$ increases more than $[\text{O}_2]$.
- (C) $[\text{SO}_2]$ and $[\text{O}_2]$ remain the same.
- (D) $[\text{SO}_2]$ and $[\text{O}_2]$ decrease equally.

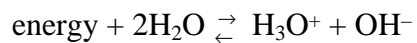
1. The equilibrium



will be shifted to the right by the

- (A) addition of a catalyst.
- (B) removal of Cl_2 .
- (C) addition of an inert gas at constant volume.
- (D) removal of PCl_5 .

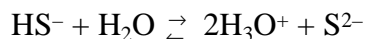
1. Consider the equilibrium:



As the temperature of a sample of pure water is increased

- (A) the number of moles of water present will increase.
- (B) the ionization constant for water will decrease.
- (C) both the number of hydrogen ions and hydroxide ions will increase.
- (D) the hydrogen ion concentration will increase and the hydroxide ion concentration will decrease.
- (E) the ionization constant for water remains unchanged.

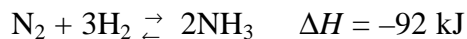
2. In the equilibrium



the addition of what ion would effectively *increase* the S^{2-} concentration?
(Hint: something that will react with a product or reactant that causes it to decrease in concentration.)

- (A) H_3O^+ (B) Br^- (C) Cl^- (D) OH^-
- (E) Na^+

3. The reaction for the formation of ammonia by direct combination is



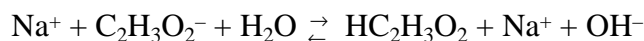
Which operation will increase the yield of ammonia in the equilibrium mixture?

- (A) doubling the concentration of hydrogen
- (B) reducing the total pressure
- (C) raising the temperature
- (D) increasing the reaction time
- (E) adding a catalyst

4. The value of the equilibrium constant K for a reaction at equilibrium is altered by

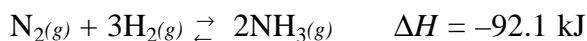
- (A) changing the effective concentration of reactants.
- (B) changing the effective concentration of products.
- (C) changing the temperature.
- (D) adding a catalyst.
- (E) adding water.

5. A solution of sodium acetate in water is observed to become more alkaline as the temperature is raised. Which conclusion can be drawn?



- (A) The forward reaction proceeds with an evolution of heat.
- (B) The forward reaction proceeds with a absorption of heat.
- (C) Acetic acid is less volatile than water.
- (D) Sodium acetate is less soluble in hot water than in cold water.
- (E) At higher temperatures the reaction $\text{Na}^+ + \text{OH}^- \rightarrow \text{NaOH}$ will occur.

6. Given the exothermic reaction:



At 400 K, the equilibrium constant is 0.53. At 800 K, what is the value of the equilibrium constant?

- (A) 0.53
- (B) greater than 0.53
- (C) less than 0.53
- (D) dependent on the concentration of ammonia in the mixture.

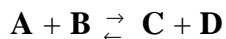
7. For this reaction, $\text{AB}_{3(g)} \rightleftharpoons \text{A}_{(g)} + 3\text{B}_{(g)}$, what is the equilibrium constant expression if the initial concentration of AB_3 is 0.1 M and the concentration of A is represented by x ?

- (A) $\frac{x \cdot 3x}{0.1 - x}$
- (C) $\frac{x \cdot x^3}{(0.1 - 3x)^3}$

$$(B) \quad \frac{x \cdot x^3}{(0.1 - x)^3}$$

$$(D) \quad \frac{x \cdot (3x)^3}{0.1 - x}$$

8. The reaction



has been studied at five widely different temperatures and the equilibrium constants tabulated.

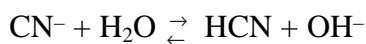
Equilibrium constant, K (at various temperatures)	
K at T_1	1×10^{-2}
K at T_2	2.25
K at T_3	1.0
K at T_4	81
K at T_5	4×10^{-1}

At which temperature will there be the maximum conversion of **A** and **B** to **C** and **D**, when equilibrium is attained?

(A) T_1 (B) T_2 (C) T_3 (D) T_4

(E) T_5

9. In the reaction



which is an acid–base conjugate pair?

(A) H_2O and HCN (C) CN^- and H_2O

(B) H_2O and OH^- (D) HCN and OH^-

10. Which species can act either as an acid or as a base in aqueous solution?

(A) HCO_3^- (B) HNO_2 (C) HIO_4 (D) H_3PO_4

11. Given that **HX** is a stronger Brønsted acid than **HY** in aqueous solution, which is true of a 1 M solution of **NaX**?

(A) It is less basic than a 1 M solution of **NaY**.

(B) It is more basic than a 1 M solution of **NaY**.

(C) It yields a neutral solution.

(D) It is more concentrated than a 1 M solution of NaY.

12. HCl is a strong acid. What is the pH of 200 mL of 0.002 M HCl?

(A) 2.0 (B) 2.7 (C) 3.4 (D) 4.0

13. The pH of a solution is 5. If the pH of this solution is decreased to 2, by what factor is the concentration of hydrogen ion affected?

(A) 2.5 (B) 3 (C) 10^{-3} (D) 10
(E) 1000

14. Which series is the correct order of **decreasing** acid strength for the respective group of acids?

(A) $\text{H}_2\text{S} > \text{H}_2\text{Te} > \text{H}_2\text{Se} > \text{H}_2\text{O}$
(B) $\text{HClO}_3 > \text{HClO}_4 > \text{H}_2\text{SO}_4 > \text{HNO}_3$
(C) $\text{HClO}_4 > \text{HClO}_3 > \text{HClO}_2 > \text{HClO}$
(D) $\text{HF} > \text{HCl} > \text{HBr} > \text{HI}$

15. The oxide of which element will react with water to form the strongest acid?

	Main Groups							
	I	II	III	IV	V	VI	VII	(O)
First Period								
Second Period	X	Y	Z	P		Q	S	U
Third Period	W					R	T	M

(A) W (B) M (C) P (D) R (E) Z

16. Which salt reacts with water (hydrolyzes) to produce a basic solution?

(A) Sodium acetate (C) Sodium nitrate
(B) NH_4Cl (D) BaSO_4

17. The addition of a small amount of acid or base will have very little effect on the pH value of a solution containing equal molar concentrations of

(A) NH_4Cl and NaCl (D) NaOH and NaCl
(B) NaOH and HCl (E) NH_3 and NaCl

(C) NH_3 and NH_4Cl

18. The pOH of an aqueous solution is 6.0. What is the $[H^+]$?

- (A) $1 \times 10^{-8} \text{ M}$ (C) $1 \times 10^{-6} \text{ M}$
(B) $1 \times 10^{-7} \text{ M}$ (D) 8 M

19. What is the correct equation for the ion product constant of water?

- (A) $[H_3O^+] + [OH^-] = 10^{-14}$
(B) $[H_3O^+] \times [OH^-] = 10^{-7}$
(C) $\frac{[H_3O^+]}{[OH^-]} = 10^{-14}$
(D) $\frac{[H_3O^+] \times [OH^-]}{[H_2O]^2} = 10^{-14}$
(E) $[H_3O^+] \times [OH^-] = 10^{-14}$

20. A 0.10 M C_6H_5COOH solution has a pH of 2.59. What is the K_a of this acid?

- (A) 6.6×10^{-6} (C) 2.6×10^{-3}
(B) 6.6×10^{-5} (D) 2.6×10^{-2}

21. Assume that standardized aqueous solutions of each of the following are available.

Substance	Ionization Constant
Na^+OAc^-	$K_b = 5.6 \times 10^{-10}$
$RNH_3^+Cl^-$	$K_a = 5.6 \times 10^{-10}$
RNH_2	$K_b = 1.8 \times 10^{-5}$
$HOAc$	$K_a = 1.8 \times 10^{-5}$

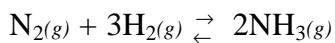
A buffer with a desired pH is 5.0 would be conveniently prepared by appropriate mixtures of

- (A) Na^+OAc^- and $HOAc$ (C) $HOAc$ and water
(B) Na^+OAc^- and RNH_2 (D) $HOAc$ and RNH_2

22. (4 pts) Identify the pH of each solution as either <7 or $=7$ or >7.0 ?

- (A) 1 M NH_4Cl _____ (C) 1 M $NaOCl$ _____
(B) 1 M K_2O _____ (D) 1 M $NaBr$ _____

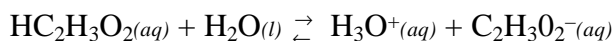
23. (6 pts) Write the Equilibrium Expression for the reaction



and calculate K_{eq} in terms of molar concentration when the equilibrium concentration moles per liter are: $\text{N}_2 = 0.02$, $\text{H}_2 = 0.01$, $\text{NH}_3 = 0.10$.

24.

Ionization Constant for Acetic Acid
$K_a = 1.85 \times 10^{-5}$



A 250.00 mL volumetric flask has a solution made from 125.00 mL of 0.100 M acetic acid and 125.00 mL of 0.100 M $\text{NaC}_2\text{H}_3\text{O}_2$. (Show your calculations.):

- a) (2 pts) What is the $[\text{H}^+]$ of the solution?
- b) (2 pts) What is the pH of the solution?
- c) (2 pts) What is the pKa of the solution?
- d) (3 pts) What would be the pH of 1.00 mL of a 0.05 M HCl solution? Qualitatively describe what would be the effect on the pH of the acetic acid: sodium acetate solution, if 1.00 mL of a 0.05 M HCl solution were added to the solution.

(2 pt Bonus) What would be the pH of a solution formed from adding 1.00 mL of a 0.05 M HCl solution to enough de-ionized water to make up 250.00 mL of solution.